Section 7

CONTENTS

FIGURES

TABLES

7. WAG 6, OU 6-01 AND OU 6-02, BORAX SITES

This chapter discusses the sites associated with the BORAX facilities, which were built and operated during the BORAX I through V experiments conducted from 1953 through 1964.

The Operating Unit (OU) 10-04 RI/FS Work Plan identified four sites associated with OU 6-01 and OU 6-02 that required evaluation, as follows:

- BORAX-02, BORAX I Reactor Burial Site
- BORAX-01, BORAX II-V Leach Pond
- BORAX-08, BORAX Ditch
- BORAX-09, BORAX II-V Reactor Building.

The locations of these sites are shown in Figure 7-1. The following sections describe each of the sites; summarize the results of previous investigations of the sites; describe the nature and extent of contamination at each site; present the preliminary contaminant screening results; and present the human health and ecological risks and uncertainty analysis for each site. Discussions of the cumulative human health and ecological risks associated with the BORAX sites are also provided in this chapter.

7.1 BORAX-02, BORAX I Reactor Burial Site (OU 6-01)

7.1.1 Site Description

The BORAX-02 site consists of the BORAX-I Reactor Burial Site, which is located about 832 m (2,730 ft) northwest of the EBR-1 reactor building (EBR-601) (see Figure 7-1). The BORAX-I reactor was constructed in 1953 as a small, simple, and inexpensive light-water reactor. This type of reactor had a uranium core that was water cooled in an open "swimming pool" type tank and could only be operated in the summer months. The core was simply designed to boil the water that acted as its coolant. In dozens of excursion tests, the project engineers stress-tested the reactor to explore reactor safety. These tests showed that the formation of steam and consequent water ejection from the core provided protection against the runaway hazard in suitably designed reactors of the water-cooled water moderated type. It was proposed that before its replacement BORAX-I be purposely subjected to a single, very quick, destructive excursion. The purpose of such an experiment was to determine its inherent safety under extreme conditions (Filemyr 1995).

The facility was deliberately destroyed in the final excursion in July 1954. The excursion was more destructive than had been predicted, and the steam explosion scattered fuel plate fragments a distance of 61 to 91 m (200 to 300 ft). Immediately following the reactor excursion, a cleanup activity commenced on July 26 in an attempt to reduce the radiation by physically removing scattered radioactive material. On August 2, 1954, a grid was established, and a radiological survey was conducted. Several fuel fragments and residues were recovered and reprocessed. Approximately 3.7 kg (7.92 mCi) of U-235 were not recovered and are potentially buried at the site. During D&D in 1955, the remaining aboveground structures were removed, and the reactor was buried in place. The 7,804-m^2 (84,000-ft^2) area contaminated from the excursion was covered with 15 cm (6 in.) of gravel in 1954; and grass, sagebrush, and other plants have grown in the area since then (Filemyr 1995).

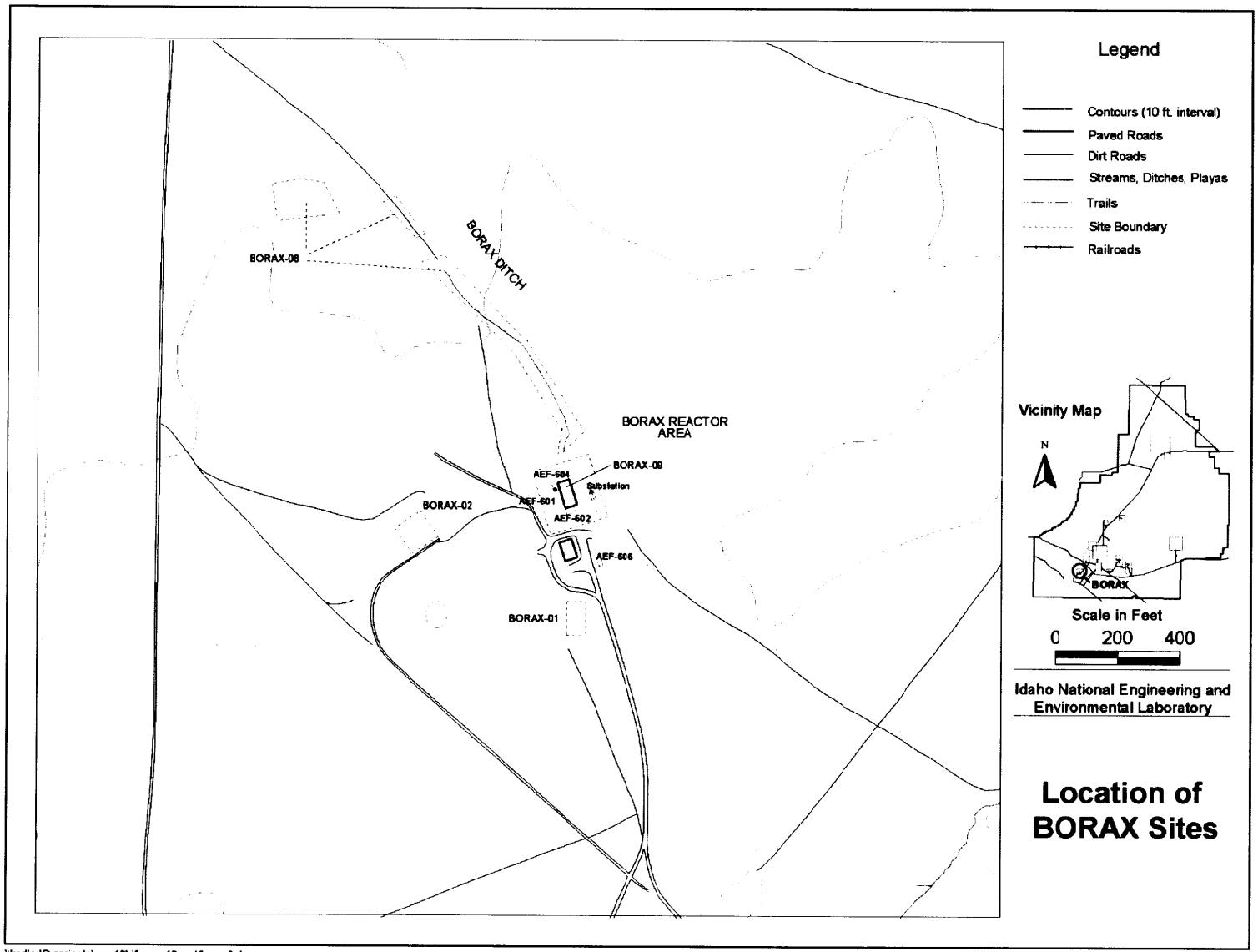

Figure 7-1. Locations of BORAX sites (OU 6-01 and OU 6-02).

The Federal Facility Agreement and Consent Order (FFA/CO) established OU 6-01 to include the 61 x 128-m (200 x 420-ft) surface soil contamination area surrounding the 30 x 30-m (100 x 100-ft) fenced burial ground. As described in Section 7.2.1, a portion of the area was remediated in 1996. The volume of buried radionuclide-contaminated soil and debris is approximately 179 m^3 (6,336 ft^3).

7.1.2 Previous Investigations (BORAX-02)

Radiological and Environmental Sciences Laboratory (RESL) conducted a multi-phase soil sampling and radiological survey of the BORAX I Reactor Burial Site in 1978. The radiological survey was conducted using a grid placed over the gravel-covered contamination area. The survey also included areas around anthills and small mammal burrows. The surveys of anthills detected highly radioactive particles, assumed to be fuel fragments brought to the surface by ants. No fragments were detected around the small mammal burrows. Cs-137 and U-235 were the only gamma-emitting radionuclides present in the gravel or debris at that time. Profile samples collected from the gravel cover indicated that most of the contamination was detected within 5 cm (2 in.) of the gravel or soil interface. A summary of that survey is provided in the text and Appendix B of the remedial investigation/feasibility study (RI/FS) for OUs 5-05 and 6-01 (Filemyr 1995).

The BORAX-I Reactor Burial Site was surveyed and sampled in both June and November of 1980. A radiological survey detected only Cs-137, and soil samples detected Cs-137, Sr-90, U-235, and Pu-239 (Filemyr 1995).

Aerial radiological surveys in the form of gamma-ray spectroscopy were conducted over the entire INEEL in 1974, 1982, 1990, and selected portions of the site in 1993. Contamination was shown to be present at the BORAX-I Reactor Burial Site, primarily due to Cs-137. An isoplethic map of the 1990 survey showed radiological contamination ranging from 1,100 to 3,500 counts per second (cps) (across the full spectrum of a multi-channel germanium lithium detector) at the burial ground (Filemyr 1995).

The BORAX-I Reactor Burial Site (BORAX-02) was evaluated in an RI/FS for OUs 5-05 and 6-01 (Filemyr 1995). In December 1995, DOE signed a Record of Decision (ROD), which included a selected remedy calling for containment by capping with an engineered, long-term barrier composed primarily of natural material (DOE-ID, EPA, and IDHW 1996). The ROD established action levels for Cs-137 (16.7 pCi/g), U-235 (13.2 pCi/g), and Sr-90 (10.8 pCi/g).

The remedial action was conducted beginning in July 1996. All shrubs, roots, signs, fencing, and other debris were removed from the contaminated area (see Figure 7-2) and placed in a layer on top of the original 30 x 30-m (100 x 100-ft) burial ground. Soil areas with radionuclide contamination exceeding the action levels were excavated to a depth of 0.3 m (1 ft) and placed over the original burial ground in 15-cm (6-in.) lifts. After the initial excavation, verification soil samples were collected, which indicated soil contamination above the action levels for Cs-137, and Sr-90 remained in three areas. These three areas were hand excavated, and the soils were placed with the other contaminated soils in the consolidation area above the original burial ground. Further sampling indicated that one "hot spot" remained. Contaminated soil from this area was excavated using a trackhoe and placed in the consolidation area. A total of 560 m^3 (733 yd^3) of contaminated soil was removed from five areas at the site and consolidated and compacted. Subsequent verification soil samples indicated that no areas remained with contamination exceeding the action levels (DOE-ID 1997).

A human intrusion barrier was constructed over the consolidated soils consisting of basalt riprap. A chain link fence was installed around the burial ground with "Keep Out" and CERCLA OU identification signs. Two granite monuments were also installed to warn potential future intruders (DOE-ID 1997).

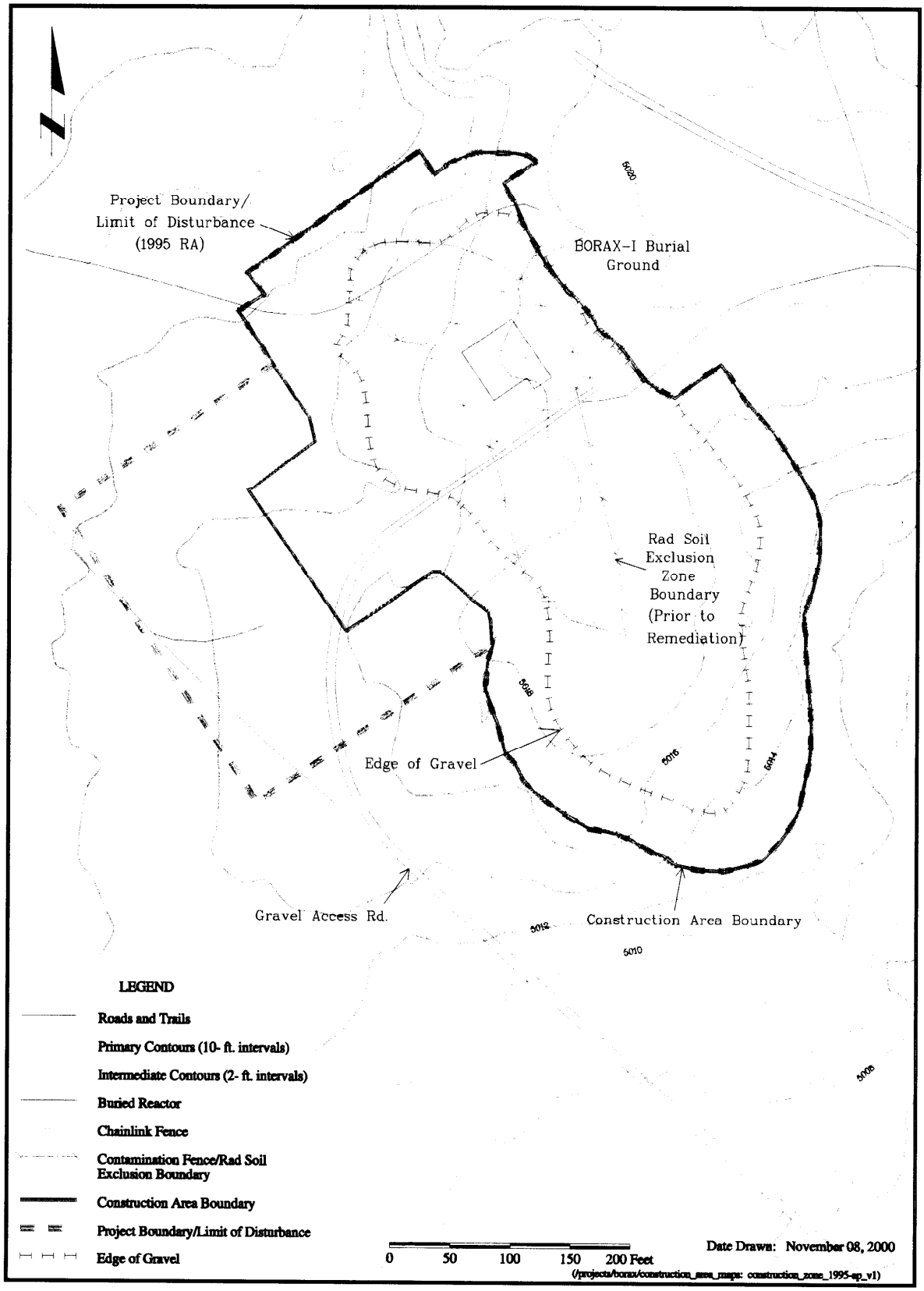

Figure 7-2. BORAX-I Reactor Burial Site (BORAX-02) (figure adapted from DOE-ID 1997).

The OU 5-05/6-01 ROD (DOE-ID, EPA, and IDHW 1996) called for annual inspections of BORAX-I engineered barrier, including radiological surveys. During the 1998 survey, an area was identified outside the fence surrounding the engineered barrier that appeared to be contaminated at levels above the ROD action level for Cs-137. The estimated maximum Cs-137 activity at this location was 160 pCi/g (Braun 1998). The 1999 inspection report did not mention this area (Akins 1999).

Researchers conducted a limited sampling and analysis effort in the summer of 2000 to address potential data gaps and to collect data in support of the ecological risk assessment (ERA) for the BORAX sites. A concern existed that small mammals burrowing under the riprap barrier could transport radionuclide contamination to the surface. For this reason, small mammals, vegetation, and collocated surface soils were sampled for metals and radionuclide analyses. This sampling effort included soil sampling in the potentially contaminated area identified in the 1998 annual inspection. Summary statistics and data compilation for soil and biotic samples collected at BORAX are provided in Appendix C.

7.1.3 Nature and Extent of Contamination (BORAX-02)

No detections of Cs-137, Sr-90, or U-235 in soils were found above the ROD action levels in areas sampled outside the BORAX-02 engineered barrier during the 2000 sampling event (see Appendix C). The maximum detections were 3.14 pCi/g Cs-137, 0.244 pCi/g U-235, and 1.24 pCi/g Sr-90. The maximum Cs-137 and Sr-90 detections were at the 0 to 0.15 m (0 to 0.5 ft) depth, and the U-235 maximum detection was at 0.15 to 0.6 m (0.5 to 2 ft).

Ra-226, which was not identified as a contaminant of concern at BORAX-02 in the OU 5-05/6-01 RI/FS (Filemyr 1995), was also detected at a maximum detection of 5.91 pCi/g at 0 to 0.15 m (0 to 0.5 ft). Previous studies have shown that Ra-226 levels can be overestimated by gamma spectrometric analysis because of interference from U-235 (Giles 1998a and 1998b). When corrected for this interference, the Ra-226 detection at BORAX-02 appears to be similar to modeled background as discussed in Giles (1998a and 1998b).

The 1996 RA reduced the risks from exposure to radionuclide-contaminated soil by removing and isolating the contamination under an engineered barrier. However, the potential exists for the radionuclide contamination remaining under the engineered barrier at BORAX-02 to migrate to groundwater, resulting in exposures via the groundwater pathway. Ecological receptors may also be exposed to the contamination remaining under the engineered barrier.

7.1.4 Preliminary Screening (BORAX-02)

The soil data collected from the 1996 postremediation field sampling efforts were screened for contaminants of potential concern (COPCs). The COPCs resulting from that screening are presented in Table 7-1. The human health risk assessment (HHRA) and ERA screening methodologies are discussed in Section 4 and presented in detail in Appendices D and F, respectively. Only Cs-137 and U-235 were retained as COPCs for the HHRA because the maximum concentrations exceeded the risk-based concentrations (RBCs). No analytes in the 1996 data were retained as COPCs for the ERA. The 2000 ecological sampling results were also screened. This screen identified strontium as a COPC for the ERA because the maximum concentration exceeded the ecologically-based screening level (EBSL). Appendix C presents the complete list of COPCs screened, and also presents the summary statistics for the data collected.

Table 7-1. Soil contaminant screening process for WAG 6, OU 6-01, BORAX-02 (BORAX-I Burial Ground) (1996 Postremediation).

		Step 1		Step 2	Step 3		Step 4		Site COPC?	
Detected Contaminants	Max Source Concentration (mg/kg or pCi/g)	INEEL Background Concentration (mg/kg or pCi/g)	Max Concentration > background?	Nontoxic Metal?	Region 9/3 RBC (mg/kg or pCi/g)	Max Concentration > RBC?	INEEL EBSL (mg/kg or pCi/g)	Max Concentration > EBSL?	HHRA	ERA
Cs-137	8.60E+00	8.20E-01	Yes	No	2.30E-01	Yes	4.95E+03	No	**Yes**	No
U-235	2.40E-01	NA	NA	No	1.30E-01	Yes	2.27E+01	No	**Yes**	No

Source: WAG 10, OU 10-04 Database.

"NA" in Step 1 indicates that a background value is not available.

Radionuclide risk-based concentrations were taken from a personal communication from Jeff Fromm, Ph.D., an environmental toxicologist, entitled "Radionuclide Risk-Based Concentration Tables." January 3, 1996.

"No RBC" indicates that an EPA Region 9 or 3 risk-based concentration based on residential soil ingestion is not available.

"No EBSL" indicates that an INEEL ecologically based screening level is not available.

7.1.5 Risk Assessment (BORAX-02)

The OU 5-05/6-01 RI/FS evaluated the human health risk at BORAX-02 without evaluating other release sites in the BORAX facility. As a result, the cumulative risk from all of the BORAX release sites had not been evaluated. In addition, the selected remedy for the site (i.e., the engineered barrier) had not been completely evaluated for its protection of ecological receptors. Therefore, BORAX-02 was retained for evaluation in the OU 10-04 RI/FS to support a cumulative HHRA for the BORAX facility and to complete the assessment of the site's impact on ecological receptors. Cumulative risks from all the BORAX sites are discussed in Section 7.6. Exposure point concentrations used in the assessment are presented in Table 7-2 and Appendix C.

Table 7-2. Summary Exposure Point Concentrations for BORAX-02 (concentration units are mg/kg or pCi/g; bin depths are in feet).

COPC	0-0.5 ft	0-4 ft	0-10 ft
Cs-137	4.18E+00	2.22E+00	8.88E-01
U-235	2.40E-01	1.96E-01	7.85E-02

7.1.5.1 Human Health. The results of the HHRA, which was performed using the 1996 postremediation sample results, indicate risk to future residents for the BORAX I Reactor Burial Site (BORAX-02) from residual contamination is 4E-05. This residual contamination is primarily due to external exposure to Cs-137. Risks to the current and future worker are 2E-04 and 2E-05, respectively, again due to external exposure to Cs-137. U-235 does not contribute significantly to risk under any of the scenarios (<2E-06). The risk from external exposure at the BORAX I Reactor Burial Site is the same as for all BORAX sites. The hazard indexes (HIs) for all scenarios are less than 1, as no COPCs with noncarcinogenic effects were identified. Complete HHRA results for the BORAX I Reactor Burial Site are presented in Appendix E.

Risks from the contamination remaining under the engineered barrier at BORAX-02 are addressed in the assessment of cumulative human health risks for all the BORAX sites (see Section 7.6).

7.1.5.2 Ecological. Only COPCs with hazard quotients (HQs) greater than 10 will be retained for further evaluation in the ERA. These HQs and COPCs are presented in Table 7-3. The COPCs with HQs less than or equal to 10 are eliminated from the ERA because they pose a low risk to ecological receptors and no longer need to be evaluated. The HQ for strontium ranged from 1 to 8. Health effects to reptiles, amphibians, birds, plants, and invertebrates could not be evaluated because of the lack of toxicity data for strontium to use for developing toxicity reference values.

Table 7-3. Summary of ERA HQs for BORAX-02

COPC Receptors	Strontium HQs
Deer mouse	4
Pygmy rabbit	8

COPCs with HQs less than one are not presented in this table.

The HQs for exposure to strontium ranged from 4 for the deer mouse (M422) to 8 for the pygmy rabbit (M122A). The exposure point concentration ranges from 92.6 mg/kg in the surface soil to 130 mg/kg in the subsurface soil. This contaminant was eliminated as a COPC, because the HQ fell below 10, which indicates a low risk to ecological receptors. No COPCs were retained in the ERA for this site. Complete ERA results are presented in Appendices F and G.

Cumulative risks to ecological receptors from exposure to contamination at all BORAX sites are addressed in the OU 10-04 Ecological Risk Assessment (see Section 17).

7.1.6 Uncertainties (BORAX-02)

The possible Cs-137 contamination detected by survey instruments during the 1998 postremediation inspection was not confirmed by the results obtained from the 2000 sampling effort. The 2000 soil sample may not have been collected at the precise location of the hot spot identified during the 1998 inspection. Therefore, it is possible that the maximum Cs-137 detection from the 2000 sampling effort underestimates the residual Cs-137 contamination in soils outside the engineered barrier.

7.1.7 BORAX-01, BORAX II-V Leach Pond (OU 6-02)

7.1.8 Site Description

BORAX-01 consists of the BORAX-II-V Leach Pond, which was used from 1954 to 1964 to collect low-level radioactively contaminated liquid discharges from the BORAX II-V experiments. The BORAX-II-V Leach Pond was located approximately 1.2 km (0.8 mi) north of EBR-1 (see Figure 7-1) and about 18 m (60 ft) south of the BORAX cooling tower. The leach pond was approximately 6×27 m (20×90 ft) in area and up to 1 m (3 ft) deep. Waste was transported from the turbine and reactor buildings to the pond via a 1.5-inch diameter iron underground pipe. The original pipe was capped, abandoned in place, and its flow diverted to an underground 2-inch diameter iron pipe around 1963. The new pipe discharged to the pond adjacent to the original pipe. Discharges to the pond during its operation were intermittent; however no records were kept pertaining to the amounts and types of effluents. The effluents were allowed to evaporate or seep into the ground. The industrial effluents were believed to be reactor building sump liquids, fluids associated with the regeneration of ion-exchange resin for water purification, and cooling tower blowdown water. As mentioned in Section 7.1, BORAX I was separate from BORAX II-V. The pond was constructed to support the BORAX II-V experiments and no effluents from the BORAX-I experiments were disposed at the site. As described in the following subsection, the pond was backfilled and graded flat with only a small monument marking its former location (Smith 1985).

7.1.9 Previous Investigations (BORAX-01)

Several investigations have been performed at the BORAX II-V Leach Pond (BORAX-01). In 1982, a radiological survey was conducted prior to D&D. Thirty three biased samples were collected from three excavated trenches at depths ranging from the surface to 2.4 m (8 ft) bgs. Several radionuclides were detected including K-40, U-235, Cs-137, Co-60, U-234, U-235, U-238, Sr-90, and Pu-239/240. Most of the contamination was concentrated within a zone approximately 0.45 m to 0.65 m (18 to 30 inches) in depth (DOE-ID 1994). Although Cs-137 was detected in a sample collected from a trench at a depth of 2.4 m (8 ft), the samplers felt that contaminated soil from the 0.45 to 0.65 m (18 to 30 inch) depth had gotten into the sample jar (Crews 1982). Because the maximum concentrations in the Leach Pond (approximately 175 pCi/g of Cs-137 in 1982) have been calculated to be within the 1E-04 to 1E-06 risk range, sampling in an attempt to determine if traces of Cs-137 exist at the 2.4 m (8 ft) depth is not suggested since it is extremely unlikely to change the risk range.

In 1988, a limited soil sampling and analysis program was conducted in order to determine the possible presence of hazardous constituents at the site. Four samples were collected at two locations near the discharge pipes from approximately 1.8 to 3 m (6 to 10 ft) bgs. The samples were analyzed for 40 CFR Appendix IX constituents, which included metals and cyanide, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), and polychlorinated biphenyls (PCBs). The summary statistics and data compilation for soil samples collected at BORAX-01 are provided in Appendix C.

The D&D activities occurred at the BORAX II-V Leach Pond in 1984 and again in 1991 through 1992. In 1984, the leach pond area was backfilled with approximately 305 m^3 (10,800 ft^3) of clean soil, graded, and reseeded to inhibit erosion (Smith 1985). The associated piping was not addressed in 1984, but was left in place until 1992, when it was removed. Other than a small volume of contaminated soil removed from under rusted pipe sections in 1992, no other contaminated soil was excavated from the leach pond area as part of the D&D operations (Arave and Rodman 1992).

The Track 1 decision document (DOE-ID 1994) for the site recommended that the leach pond (BORAX-01) be addressed under the OU 10-06 RI/FS. An Engineering Evaluation/Cost Analysis (EE/CA) for OU 10-06 concluded that risks posed by contamination at the BORAX II-V Leach Pond were within the 1E-4 to 1E-6 risk range. The decision was later made to incorporate the BORAX-01 site into this RI/FS (see discussion in Chapter 3).

Although not purposely focused on the BORAX-II-V Leach Pond, a limited sampling and analysis effort was conducted in the summer of 2000 at BORAX. The sampling addressed potential data gaps and collected data in support of the ERA for the entire BORAX area. Part of the effort included a field measurement system, the Global Positioning Radiometric Scanner, which used an onboard computer, a global positioning system (GPS), and a scintillation detector system to map the distribution of gamma-emitting radioactive contamination in the surface soils. No surface contamination was detected in the leach pond area. The summary statistics and data compilation for soil and biotic samples collected at BORAX in 2000 are provided in Appendix C.

7.1.10 Nature and Extent of Contamination (BORAX-01)

The 1982 investigation identified radionuclide contamination in the soil, concentrated at depths between 0.3 to 0.75 m (1 to 2.5 ft). Cs-137 was detected in 26 samples collected between 0 to 2.4 m (0 to 8 ft) with a maximum value of 175 pCi/g at a depth of 0.6 m (2 ft). There were three to six detections each of Pu-238, Pu-239, Sr-90, U-234, U-235 and U-238 at levels below 2 pCi/g. Co-60 was detected in four samples (0.6 m to 2.4 m; 2 to 7.9 ft) with a maximum value of 25 pCi/g at the 0.6-m (2-ft) depth. K-40 was detected in all of the soil samples with a maximum concentration of 21 pCi/g (Crews 1982). The maximum detections for Co-60, Cs-137, U-235 and U-238 occurred at the 0.6-m (2-ft) depth, while the U-234 and Sr-90 maximum detected values (1.44 pCi/g and 0.3 pCi/g, respectively) were located at 2.1 m (7 ft). Both the Pu-238 and Pu-239/240 maximum detected values were associated with the surface interval of 0 to 0.15 m (0 to 0.5 ft) bgs.

The 1988 investigation indicated metals and possible VOC contamination at depth. The only SVOC detected in the 1988 data was 2,4-dichlorophenol (0.38 mg/kg) at a depth of 2 to 2.2 m (6.5 to 7.5 ft). There were seven very low detections (less than or equal to 0.006 mg/kg) of VOCs including toluene, methylene chloride, and chloromethane all at the 2 to 2.9 m (6.5 to 9.5 ft) depth. These VOC detections may be associated with laboratory blank contamination; however, no external data blank contamination validation qualifiers were placed on the records. There were no detections of cyanide, sulfide antimony, beryllium, silver, tin, selenium, or thallium. Arsenic, barium, chromium, cadmium, copper, lead, nickel, vanadium and zinc were detected above background in all four samples. Mercury was detected in three of four samples and cobalt detected in only one of four samples. All sample results were associated with two depth intervals, 2 to 2.2 m (6.5 to 7.5 ft) and 2.3 to 2.9 m (7.7 to 9.5 ft)

(DOE-ID 1994). Maximum detected values for these analytes (all at the 2 to 2.2 m interval) were as follows:

- Arsenic 13 mg/kg
- Barium 241 mg/kg
- Cadmium 6.9 mg/kg
- Chromium 24.6 mg/kg[1]
- Cobalt 15.2 mg/kg
- Copper 16.7 mg/kg
- Lead 16.5 mg/kg
- Mercury 0.7 mg/kg
- Nickel 29.1 mg/kg
- Vanadium 36.4 mg/kg
- Zinc 87.2 mg/kg.

To summarize, contamination at the BORAX-01 site appears to be primarily metals and radionuclides located in the subsurface. Some contamination may be located at the original surface of the leach pond, which was backfilled in 1984, although the depth to the original surface is not known. Some vertical migration of contaminants may have occurred when the leach pond was in operation. Any effluent that did not evaporate infiltrated into the subsurface, where contaminants were likely to have adsorbed to the soil particles within the vadose zone. After the cessation of the BORAX program in 1964, there were no more effluent discharges to drive subsurface migration of contaminants. Further contaminant migration may have occurred with percolation of precipitation into the soil column. Because of the low rate of precipitation and high evaporation rates at the INEEL, migration is expected to be minimal. The potential for windblown surface contamination is low at the site because contamination is located in the subsurface, and the site is covered with vegetation, chiefly crested wheatgrass and rabbitbrush.

7.1.11 Preliminary Screening (BORAX-01)

The soil data collected from the 1982 and 1988 field sampling efforts at the BORAX II-V Leach Pond were screened for COPCs. The COPCs resulting from that screening are presented in Table 7-4. Appendix C contains the complete screening table for BORAX-01. The HHRA and ERA screening methodologies are discussed in Section 4 and presented in detail in Appendices D and F, respectively. Cs-137, U-235, and U-238 were retained as COPCs for the HHRA because the maximum concentrations

[1] This value represents total chromium, which may include chromium (III) as well as chromium (VI). This RI/FS assesses chromium as chromium (III) because chromium (VI) is not expected to persist in the INEEL environment (Bartlett and Kimble 1976; Rai et al. 1989).

Table 7-4. Soil contaminant screening process for OU 10-04, BORAX-01 (Leach Pond).

		Step 1		Step 2	Step 3		Step 4		Site COPC?	
Detected Contaminants	Source Concentration (mg/kg or pCi/g)	INEEL Background Concentration (mg/kg or pCi/g)	Max Concentration > background?	Nontoxic Metal?	Region 9/3 RBC (mg/kg or pCi/g)	Max Concentration > RBC?	INEEL EBSL (mg/kg or pCi/g)	Max Concentration > EBSL?	HHRA	ERA
2,4-Dichlorophenol	6.80E-02	NA	NA	No	1.83E+02	No	No EBSL	No EBSL	No	Yes
Arsenic	1.30E+01	5.80E+00	Yes	No	3.90E-01	Yes	8.44E-01	Yes	*	*
Cadmium	6.90E+00	2.20E+00	Yes	No	3.90E+01	No	2.36E-03	Yes	No	Yes
Chloromethane	2.00E-03	NA	NA	No	1.23E+00	No	No EBSL	No EBSL	No	Yes
Cobalt	1.52E+01	1.10E+01	Yes	No	4.69E+03	No	4.27E-01	Yes	No	Yes
Cs-137	1.75E+02	8.20E-01	Yes	No	2.30E-01	Yes	4.95E+03	No	Yes	No
Mercury	7.00E-01	5.00E-02	Yes	No	6.10E+00	No	3.00E-01	Yes	No	Yes
U-235	6.00E-01	NA	NA	No	1.30E-01	Yes	2.27E+01	No	Yes	No
U-238	1.40E+00	1.40E+00	Yes	No	6.70E-01	Yes	2.32E+01	No	Yes	No

Source: WAG 10, OU 10-04 Database.

*Arsenic was removed from the ERA & HHRA COPC lists because detected levels are within the arsenic regional background ranges discussed in Appendix K.

"NA" in Step 1 indicates that a background value is not available.

"No RBC" indicates that an EPA Region 9 or 3 risk-based concentration based on residential soil ingestion is not available.

"No EBSL" indicates that an INEEL ecologically based screening level is not available.

Radionuclide risk-based concentrations were taken from a personal communication from Jeff Fromm, Ph.D., an environmental toxicologist, entitled "Radionuclide Risk-Based Concentration Tables." January 3, 1996.

exceeded the RBCs. Cadmium, cobalt, and mercury were retained as COPCs for the ERA because the maximum concentrations exceeded the EBSLs. Chloromethane, and 2,4-dichlorophenol were also retained as COPCs for the ERA because EBSLs have not yet been established for these contaminants.

7.1.12 Risk Assessment (BORAX-01)

Table 7-5 presents the exposure point concentrations used in the HHRA and ERA. Appendix C contains both summary statistics and exposure point concentrations used for the HHRA and ERA.

Table 7-5. Summary Exposure Point Concentrations for BORAX-01 (concentration units are mg/kg or pCi/g; bin depths are in feet).

COPC	0-0.5 ft	0-4 ft	0-10 ft
2,4-Dichlorophenol	NA	NA	2.28E-01
Cadmium	NA	NA	4.14E+00
Chloromethane	NA	NA	1.20E-03
Cobalt	NA	NA	9.12E+00
Cs-137	2.24E+00	9.54E+01	3.95E+01
Mercury	NA	NA	4.20E-01
U-235	2.50E-01	3.13E-01	3.15E-01
U-238	1.21E+00	1.38E+00	1.21E+00

NA indicates no samples were taken at this soil depth.

7.1.12.1 Human Health. The results of the HHRA for the BORAX II-V Leach Pond indicate risk to future residents is 4E-05, primarily due to external exposure to Cs-137. Risks to the current and future worker are 2E-04 and 2E-05, respectively, again due to external exposure to Cs-137. U-235 and U-238 do not contribute significantly to risk under any of the scenarios. The risk from external exposure at the BORAX II-V Leach Pond is the same as for all BORAX sites. The HIs were not calculated, because no COPCs with noncarcinogenic effects were identified. Complete HHRA results for the BORAX II-V Leach Pond are presented in Appendix E.

7.1.12.2 Ecological. The COPCs for the ERA are metals and VOC contamination in subsurface soil (from 2 to 2.9 m). Only COPCs with HQs greater than 10 will be retained for further evaluation in the ERA. These HQs and COPCs are presented in Table 7-6. The COPCs with HQs less than or equal to 10 are eliminated from the ERA because they pose a low risk to ecological receptors and no longer need to be evaluated. The HQs for cadmium, cobalt, and mercury ranged from 1 to 800. Risks from these contaminants to reptiles, amphibians, and invertebrates could not be evaluated (along with risks to plants from cobalt) because of the lack of toxicity data to develop toxicity reference values. The 2,4 dichlorophenol and chloromethane were among the COPCs, but no toxicity information could be found to assess ecological risk.

Table 7-6. Summary of ERA HQs for BORAX-01.

COPC Receptors	Cadmium HQs	Cobalt HQs	Mercury HQs
Deer mouse	800[a]	4	1
Plants	—	—	1
Pygmy rabbit	300[a]	8	2
Sage sparrow	1	—	—
Townsend's western big-eared bat	9	—	—

The COPCs with HQs less than one are not presented in this table.

a. See the discussion on cadmium following this table that explains why this HQ is not retained in the ERA.

The HQs for the COPCs at BORAX-01 are discussed below:

- The HQs for exposure to cadmium ranged from 1 for the sage sparrow (AV222), to 9 for Townsend's western big-eared bat (M210A), 300 for the pygmy rabbit (M122A) and 800 for the deer mouse (M422). The exposure point concentration in the subsurface soil is 4.14 mg/kg. The INEEL upper tolerance limit (UTL) background concentration for cadmium is 2.2 mg/kg. The exposure modeling is considered conservative and therefore may result in overestimated risk to ecological receptors. Also, the risk may be ameliorated by depth to contamination (2 to 2.9 m; 6.7 to 9.5 ft) because neither deer mice nor pygmy rabbits are deep burrowers; they are not expected to reach the contamination. Plant HQ values were below 1 and were subsequently not viewed as a risk. Rooting depths of plants are not expected to reach the depths where concentrations of cadmium were detected. This COPC would be unlikely to pose a significant risk to any of these ecological receptors and will no longer be evaluated.

- The HQs for exposure to cobalt ranged from 4 for the deer mouse (M422) to 8 for the pygmy rabbit (M122A). The exposure point concentration in the subsurface soil is 9.12 mg/kg. The INEEL background concentration for cobalt is 11 mg/kg. Therefore, an average species may be exposed to the same magnitude of risk from exposure to background. This contaminant was eliminated as a COPC, because the HQs fell below 10, which indicates a low risk to ecological receptors. The HQs for exposure to mercury ranged from 1 for the deer mouse (M422) and plants (all vegetation) to 2 for the pygmy rabbit (M122A). The exposure point concentration in the subsurface soil is 0.42 mg/kg. The INEEL background concentration for mercury is 0.05 mg/kg. This contaminant was eliminated as a COPC, because the HQs fell below 10, which indicates a low risk to ecological receptors.

The risk evaluation indicates that the BORAX II-V Leach Pond has limited risk to ecological receptors from exposure to contaminated subsurface soil in the leach pond. No COPCs were retained in the ERA for this site. Cumulative risks to ecological receptors from exposure to contamination at all BORAX sites are addressed in the OU 10-04 Ecological Risk Assessment (Section 17).

7.1.13 Uncertainties

No records were kept pertaining to the amounts and types of effluents discharged to the pond during its operation. The effluents were allowed to evaporate or seep into the ground. Some

contamination may be located at the original surface of the leach pond, which was backfilled in 1984; the depth to the original surface is not known. Some vertical migration of contaminants may have occurred. However, because of the low rate of precipitation and high evaporation rates at the INEEL, migration is expected to be minimal.

7.2 BORAX-08, BORAX II-V Ditch (OU 6-02)

7.2.1 Site Description

The BORAX-08 site, known as the BORAX II-V Ditch, was the site of a radionuclide-contaminated drainage ditch associated with the BORAX II through V reactor experiments. The site consists of an unlined ditch beginning approximately 12 m (40 ft) north of the former BORAX II-V facility (see Figure 7-1). The ditch is approximately 477 m (1,565 ft) in length, about 1 m (3.25 ft) wide for most of its length, and spreads to 15 m (50 ft) in width at its end where the topography flattens.

A 10-cm (4-in.) raw water line led from the reactor to a 23-cm (9-in.) corrugated underground metal pipe that emptied into the ditch just outside the north security fence of the BORAX II-V facility. There are no records of the constituents or volumes released to the ditch.

7.2.2 Previous Investigations (BORAX-08)

Previous investigations at the BORAX-08 site included radiological surveys, which indicated the ditch contained radionuclide contamination up to 1,900 cpm. Metals contamination was also suspected based on historical information from the BORAX experiments. The agencies determined the ditch should be included as a new CERCLA site, and it was included in the OU 6-02 under the site code of BORAX-08.

Contamination in the BORAX ditch was characterized during the Phase II sampling of the OU 10-06 EE/CA (INEL 1995b). Soils were initially sampled to a depth of 1.2 m (4 ft) and analyzed for radionuclides and metals contamination. After the results confirmed radionuclide contamination at 1.2 m (4 ft), additional samples were collected at one location down to the 1.5 to 1.8-m (5 to 6-ft) interval, which corresponded to the depth of basalt bedrock. Results of the sampling effort indicated radionuclide contamination in the soil, including Am-241/Pu-238, Co-60, Cs-137, Pu-239, Th-228, Th-232, Th-230, and U-238. Detected metals included antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, lead, manganese, nickel, selenium, vanadium, and zinc.

The OU 10-06 EE/CA (INEL 1995b) included estimation of human health risks associated with exposure of current workers and future residents to radionuclides and metals. The results of the risk assessment indicated risks above the 1E-04 to 1E-06 target risk range under the current occupational scenario and future residential scenario from exposure to radionuclides. The primary contributor to risk was external exposure to Cs-137. The EE/CA (INEL 1995b) indicated that risks from exposure to metals were within the risk range for the current occupational scenario and at the upper end of the risk range for future residents. The main contributor to risk was arsenic. However, the arsenic levels were attributed to natural soil-forming processes, rather than past waste disposal practices (INEL 1995b).

Based on the results of the EE/CA (INEL 1995b), a decision was made to perform an non-time-critical removal action (NTCRA) at the BORAX-08 site. The NTCRA was conducted at the site between August 28 and September 18, 1995. The NTCRA involved the use of the Phase II characterization data and hand-held sodium iodide radiation detection equipment to guide the removal of approximately 890 m^3 (1,178 yd^3) of radionuclide-contaminated soil from the ditch. The NTCRA focused on Cs-137 as the

contaminant of concern. Radionuclide-contaminated soils were excavated and transported to the Test Reactor Area (TRA) Warm Waste Pond, which has since been capped (DOE-ID 1997).

Following the excavation and using a guideline of one sample per each excavated 75.6 m^3 (100 yd^3), 12 composite soil samples were collected for gamma-spectroscopy analysis. The analysis detected only Cs-137; no other gamma-emitting radionuclides thought to originate from BORAX activities were detected in the verification samples. Concentrations of Cs-137 ranged from 0.1 ± 0.02 pCi/g up to 8.1 ± 0.6 pCi/g. The highest level of Cs-137 (8.1 ± 0.6 pCi/g) was approximately 2.1 times less than the OU 10-06 PRG of 16.7 pCi/g and 9.9 times greater than the 0.82 pCi/g area background (Rood 1995). The mean concentration of Cs-137 in the BORAX Ditch composite verification samples was approximately 1.3 pCi/g. These data indicated that the OU 10-06 PRGs were met with the NTCRA at the BORAX II-V Ditch. After the removal action, the disturbed portions of the BORAX ditch area were either backfilled or graded flat and then reseeded with native flora. In addition, after the removal action, the ditch no longer met the criteria for posting as a soil contamination area, and radiation control technicians removed the fencing and signs.

The BORAX-08 area was included in the sampling effort conducted in the summer of 2000 at BORAX. The sampling addressed potential data gaps and collected data in support of the ERA for the entire BORAX area. Part of the effort included a field measurement system, the Global Positioning Radiometric Scanner, which used an onboard computer, a GPS, and a scintillation detector system to map the distribution of gamma-emitting radioactive contamination in the surface soils.

7.2.3 Nature and Extent of Contamination (BORAX-08)

Remaining contamination at the BORAX II-V Ditch (BORAX-08) was shown to be below the action level of 16.7 pCi/g for Cs-137 through verification sampling during the 1995 NTCRA. Because the NTCRA was focused on Cs-137 as the contaminant of concern, no data were collected to determine arsenic levels remaining after the radionuclide-contaminated soils were removed. However, arsenic detections in INEEL soils are not considered reliable indicators of contamination and are more likely attributable to inherent soil properties (see discussion in Appendix K).

The FY-00 Global Positioning Radiometric Scanner survey identified no areas with radioactivity above background levels near the BORAX-08 site.

7.2.4 Preliminary Screening (BORAX-08)

The soil data collected from the 1993 "windblown soils" and the 1995 postremediation field sampling efforts were screened for COPCs. The results of that screen are presented in Table 7-7. The maximum detection value for Cs-137 shown in Table 7-7 was obtained from a soil boring located between the BORAX II-V Reactor Building and the head of the BORAX II-V Ditch. The HHRA and ERA screening methodologies are discussed in Section 4 and presented in detail in Appendices D and F, respectively. Only Cs-137 was retained as a COPC for the HHRA because the maximum concentration exceeded the RBC. No analytes were retained as COPCs for the ERA.

7.2.5 Risk Assessment (BORAX-08)

Summary statistics and exposure point concentrations for this site are presented in Appendix C. The exposure point concentrations for Cs-137 used in the HHRA are 7.22 pCi/g for 0-0.5 ft depth, 1.36E+01 pCi/g for 0-4 ft depth, and 5.44 pCi/g for 0-10-ft depth.

7.2.5.1 Human Health. The results of the HHRA for the BORAX II-V Ditch indicate that the risk to future residents is 4E-05, primarily due to external exposure to Cs-137. Risks to the current and future worker are 2E-04 and 2E-05, respectively, again due to external exposure to Cs-137. The risk from external exposure at the BORAX II-V Ditch is the same as for all BORAX sites. HIs were not calculated for this site, because no COPCs with noncarcinogenic effects were identified. Complete HHRA results for the BORAX II-V Ditch are presented in Appendix E.

7.2.5.2 Ecological. No COPCs were identified for ecological receptors at BORAX-08. Cumulative risks to ecological receptors from exposure to contamination at all BORAX sites are addressed in the OU 10-04 Ecological Risk Assessment (Section 17).

7.2.5.3 Uncertainties. No data are available to determine whether contaminants entered the vadose zone beneath the BORAX II-V Ditch. According to the engineering evaluation/cost analysis (EE/CA) (INEL 1995b), much of the radionuclide contamination was concentrated near the surface. However, radionuclides were detected in three samples collected just above basalt. Therefore, some contamination may have migrated into the basalt that was not removed during the NTCRA.

It is unlikely that any contamination remaining in the vadose zone (basalt) at BORAX-08 would significantly contribute to risk at the BORAX sites. The 1996 sample results demonstrated that Cs-137 was the primary contaminant and that much of the Cs-137 was concentrated in the surface soils. Cs-137 detections nearer the basalt were much lower than in surface soils, which may indicate that much of the Cs-137 was adsorbed in the surface soils, and little may have migrated into the vadose zone. Any Cs-137 contamination in the vadose zone is unlikely to significantly contribute to risk from external exposure, which is the primary contributor to risk at the BORAX sites, because of shielding with depth. Migration to groundwater is also unlikely, given the significant depth to groundwater, the high evaporation rates at INEEL, and the discontinuation of discharges to the BORAX-08 Ditch.

7.3 BORAX-09, BORAX II-V Reactor Building (OU 6-02)

7.3.1 Site Description

The BORAX facility was the site of the BORAX-II through BORAX-V reactor experiments conducted between 1953 and 1964. The BORAX-09 site (see Figure 7-1) consists of the entombed belowground structures remaining from Argonne Experimental Facility (AEF)-601, include subfloor concrete foundations and reactor components, and other remaining artifacts of the BORAX V experiment. Concrete shield blocks seal the AEF-601 pits, trenches, and access shaft, all of which have been backfilled with soil. The 0.4-ha (0.9-acre) area surrounding AEF-601 is fenced with chain-link and barbed wire and is posted as a radiation area to restrict entry. Underground items left at the site include two reactor vessels, a water storage pit (now dry), an equipment pit, a subreactor room, a utility pipe trench, a stream pipe trench, and a dry storage pit. The aquifer is approximately 196 m (640 ft) bgs at the BORAX sites.

In FY-85, the facility was designated for decommissioning. A D&D removal and containment action was conducted at BORAX-09 beginning in April 1996 and concluding in May 1997. The objective of these activities was to reduce the predicted radiation exposure risk to future workers and residents to well below the National Contingency Plan (NCP) target risk range. This was accomplished by removing all remaining aboveground structures and systems and entombing the subfloor levels of the reactor building. No radiological health and safety hazards to the public or INEEL workers remain on the surface of the facility (Rodman 1997).

Table 7-7. Soil contaminant screening process for OU 10-04, BORAX-08-Ditch.

		Step 1		Step 2	Step 3		Step 4		Site COPC?	
Detected Contaminants	Max Source Concentration (mg/kg or pCi/g)	INEEL Background Concentration (mg/kg or pCi/g)	Max Concentration > background?	Nontoxic Metal?	Region 9/3 RBC (mg/kg or pCi/g)	Max Concentration > RBC?	INEEL EBSL (mg/kg or pCi/g)	Max Concentration > EBSL?	HHRA	ERA
Cs-137	1.45E+01	8.20E-01	Yes	No	2.30E-01	Yes	4.95E+03	No	Yes	No

Source: WAG 10, OU 10-04 Database.

"NA" in Step 1 indicates that a background value is not available.

Radionuclide risk-based concentrations were taken from a personal communication from Jeff Fromm, Ph.D., an environmental toxicologist, entitled "Radionuclide Risk-Based Concentration Tables." January 3, 1996.

"No RBC" indicates that an EPA Region 9 or 3 risk-based concentration based on residential soil ingestion is not available.

"No EBSL" indicates that an INEEL ecologically based screening level is not available.

The lead shielding removed from the BORAX V reactor pit was sent off-Site for recycling. The mixed waste streams (cadmium-containing resin and filter) were transferred to the Waste Experimental Reduction Facility (WERF) for treatment by incineration. The radionuclide Co-60 was detected at an activity level of approximately 0.85 ± 0.09 pCi/g in one lead brick that had been used to cover an instrument port on the reactor vessel top. This brick was disposed of as mixed waste. No other gamma-emitting radionuclides were detected in any of the other lead bricks or shield blocks. Belowgrade pits and trenches were backfilled with soil. Less than approximately 3.8 m^3 (5 yd^3) of radiologically contaminated soil excavated from the head of the BORAX-08 Ditch was placed in the reactor building access shaft. The soil contained concentrations of Cs-137 up to 14.5 ± 1.1 pCi/g. The remainder, approximately 32.6 m^3 (42.6 yd^3), was clean fill soil. The concrete shield blocks were replaced over these areas. The remaining reactor building systems, including two reactor vessels (BORAX II/III/IV and BORAX V) and approximately 22 m^3 (780 ft^3) of materials that contained asbestos, were buried in the belowgrade concrete structure (Rodman 1997).

The maximum radionuclide concentrations from the reactor pit soils measured 161 pCi/g for Cs-137 and 0.82 pCi/g for Co-60. The sampling analysis results indicated that levels of metals contained in the soil were at or near INEEL background levels. No toxicity characteristic leaching procedure (TCLP) metals above regulatory levels were detected. Results of the Sr-90 analysis indicated that the levels of Sr-90 contained in the soil were close to background levels. Total alpha spectrometric analyses of selected soil samples indicated that alpha-emitting radionuclides detected were consistent with expected INEEL background levels (Rodman 1997).

The remaining support systems (septic system, electrical substation, raw- and waste-water lines, and miscellaneous concrete pads) external to the reactor building were dismantled and disposed, either in the reactor building as fill material, at the INEEL Sanitary Landfill, or at Property Disposal Facility. A 5-cm (2-in.) thick steel lid, designed to provide shielding for the top of the reactor vessel, was placed in the vessel. Thirty-three waste boxes containing the concrete cap and soil removed from the BORAX-II through IV reactor pit were sampled and then emptied back into the pit. The top 1.2-m (4-ft) portion of the reactor pit was filled with clean fill material and the shield blocks were replaced (Rodman 1997).

The chain-link fence on the perimeter of the reactor building site was left in place. An area of about 1.2 ha (3 acres) was contoured to match the surrounding areas, then reseeded with native grasses to comply with the storm water prevention plan for this site (INEL 1995a).

7.3.2 Previous Investigations (BORAX-09)

Prior to D&D of the BORAX II-V facility in 1996, several investigations and sampling events were conducted to characterize the extent of contamination in the facility. The facility was first characterized for radiological contamination in May 1979 by taking direct radiation measurements and conducting surface contamination checks in various locations and facility systems. Radiological surveys were also performed from 1991 through 1993. Maximum radiation levels detected during the 1992 survey were 9.3 R/hr for the BORAX II through IV reactor vessel and 15 R/hr for the BORAX-V vessel (Rodman 1997).

Various decommissioning tasks were performed at the BORAX-V facility from 1985 through 1992. During the earlier part of this process, transformers were sampled for PCBs prior to removal (INEL 1994).

In July 1991, an analysis of subreactor room floor liquids showed 73 +/- 9 pCi/L of Cs-137 contamination. Followup samples collected in November 1991 did not contain detectable gamma-emitters, contained only gross alpha and beta activity that was below detection limits, and did not exhibit

the characteristics of toxicity, ignitability, corrosivity, or reactivity. Even when samples are collected within minutes of each other, many data sets collected from heterogeneous media include both detect and nondetects, especially when the contaminant levels are near the detection limit. Although some of the contamination was taken away in the initial sampling event, no decontamination happened between July and November 1991. In July and November, there could have been differences in the sampling technique, sampling equipment, analytical technique, and sampled population, but the detection and nondetection of Cs-137 in the samples most likely was due to heterogeneity in the sampled population and the low level of contamination.

Samples collected in 1992 indicated scale on the equipment pit sump wall contained lead and cadmium (7,390 and 6,210 ug/L, respectively) presumably from lead-based paints containing cadmium pigment. Subreactor room sump samples collected in 1992 contained 300 +/- 30 pCi/L of Cs-137, 84 +/- 8 pCi/L of Co-60, and 479 ug/L mercury. The mercury contamination is presumed to result from broken instruments and gauges. Smear and wipe samples were collected and radiation measurements were also taken. Cs-137 and Co-60 were detected in one sample (14.1 pCi/g, 0.67 pCi/g, respectively) obtained from the floor of the subreactor room in 1992.

Additional samples collected in 1993 containing mercury did not exceed TCLP regulatory levels. In November 1994, radiation dose rates were 0.07 and 0.01 mrem/hour at 0.9 m (3 ft) above the concrete shield blocks covering the BORAX II through IV and the BORAX V reactor vessels, respectively.

An analysis using Microshield software was performed in 1994 to model surface exposure rates for gamma radiation. In November, dose rates were measured above the concrete slabs over the reactor vessels.

Following completion of D&D activities in 1996, surface soils at the site were characterized to determine levels of residual contamination. Composite samples were collected from 30 random locations at the site. All the samples were analyzed for gamma-emitting radionuclides, and five of the samples were also analyzed for Contract Laboratory Program metals. Cm-244 was not detected in the four samples for which results were available. During the 1996 post-D&D sampling event, Cs-137 was detected in all 21 samples for which results were available, ranging from 0.15 to 1.79 pCi/g. There was one detection of Pu-239/240 (0.034 pCi/g) in 4 samples. Sr-90 was detected in all four samples with a maximum value of 1 pCi/g. Th-230, Th-232, U-234, and U-238 were detected in all four samples with maximum values of 1.54 pCi/g, 1.52 pCi/g, 1.61 pCi/g, and 1pCi/g, respectively. U-235 was detected in three of four samples with a maximum value of 0.0644 pCi/g. All sample depths were given as 0 to 0.1 m (0 to 0.33 ft) (Blackmore 1997).

Maximum values for detected inorganics for the 1996 post-D&D sampling are as follows:

- Aluminum 15,900 mg/kg
- Arsenic 7.7 mg/kg
- Barium 225 mg/kg
- Beryllium 0.79 mg/kg
- Cadmium 1.1 mg/kg
- Calcium 48,600 mg/kg

- Chromium 24.5 mg/kg[2]
- Cobalt 10.7 mg/kg
- Copper 20.6 mg/kg
- Iron 21,400 mg/kg
- Lead 14.1 mg/kg (3 results only)
- Magnesium 94450 mg/kg
- Manganese 497 mg/kg
- Mercury 1.2 mg/kg (single detect)
- Nickel 22 mg/kg
- Potassium 2670 mg/kg
- Sodium 676 mg/kg
- Vanadium 37.3 mg/kg
- Zinc 87.4 mg/kg.

There were no detections of thallium, antimony, silver, or selenium. All 1996 soil samples were collected at a depth of 0 to 0.1 m (0 to 0.33 ft).

In the summer of 2000, a limited sampling and analysis effort was conducted to address potential data gaps and to collect data in support of the ecological risk assessment for the entire BORAX area. The summary statistics and exposure point concentrations for contaminants at BORAX-09 are provided in Appendix C.

7.3.3 Nature and Extent of Contamination (BORAX-09)

The primary area of contamination is belowground and buried with the reactor debris. The remaining radionuclide contamination entombed at the site can be estimated from data collected during the 1996 D&D activity (see discussion under Section 7.3.5.1). Migration of this contamination to groundwater is very unlikely because all contamination is contained within the concrete subfloor of the original reactor building, and concrete shield blocks are also in place above the contamination (Rodman 1997).

Samples collected in 1996 from surface soils at the site indicate low levels of Cs-137 and several other radionuclides in very low concentrations. Manganese is slightly elevated relative to INEEL

[2] This value represents total chromium, which may include chromium (III) as well as chromium (VI). This RI/FS assesses chromium as chromium (III) because chromium (VI) is not expected to persist in the INEEL environment (Bartlett and Kimble 1976; Rai et al., 1989).

background levels. With the exception of the 1996 mercury value of 1.2 mg/kg, all other mercury concentrations are at or below background levels.

7.3.4 Preliminary Screening (BORAX-09)

The soil data collected from the 1992 and 1996 field sampling efforts were screened for COPCs. The COPCs resulting from that screening are presented in Table 7-8. Appendix C presents the complete list of COPCs screened. The HHRA and ERA screening methodologies are discussed in Section 4 and presented in detail in Appendices D and F, respectively. Cs-137 was retained as a COPC for the HHRA because the maximum concentration levels exceeded the RBC. Manganese and mercury were retained as COPCs for the ERA because the maximum concentration levels exceeded the EBSLs. Cs-137 was retained from the preliminary screening as a human health COPC based on the single value of 14.1 pCi/g for a sample collected from the subsurface. This value, if decay-corrected to the year 2000, would equal approximately 11 pCi/g.

7.3.5 Risk Assessment (BORAX-09)

Table 7-9 presents the exposure point concentrations used for the HHRA and the ERA. Appendix C contains both summary statistics and exposure point concentrations used for the HHRA and the ERA.

7.3.5.1 Human Health. The results of the HHRA for the BORAX II-V Reactor Building (BORAX-09) indicate that the risk to future residents is 4E-05, due to external exposure to Cs-137. Risks to the current and future worker are 2E-04 and 2E-05, respectively, again due to external exposure to Cs-137. The risk from external exposure at the BORAX II-V Ditch is the same as for all BORAX sites. HIs were not calculated for this site, because no COPCs with noncarcinogenic effects were identified. Complete HHRA results for the BORAX II-V Reactor Building are presented in Appendix E.

To supplement the HHRA results, an additional analysis was performed to further assess human health risks to future residents from the entombed BORAX reactor facility. The exposure pathway is from external exposure to radiation produced by the buried reactor vessels and radionuclide-contaminated fill sand in the BORAX-II/IV reactor pit. The groundwater pathway was not considered because the contamination is entombed in concrete. The scenario for exposure is a resident 100 years into the future. The BORAX facility will remain under administrative controls for at least the next 100 years. There are two versions of the residential exposure scenario. The first example would be a future resident building a house directly on top of the old reactor building foundation and floor with the house being centered directly over the BORAX II-IV reactor pit. The second would be a future resident building, a home with a 3.05 m (10-ft) deep basement at the BORAX-V end of the old reactor building foundation.

Microshield Version 5.03b (Grove Engineering 1995–1999) was used to estimate the exposure at the surface due to gamma radiation produced by the entombed reactor vessels and the radionuclide-contaminated fill soil. The analysis of the two reactor vessels and the total fill soil volume were modeled separately and an exposure from each of these three sources was calculated. The maximum expected exposure from each of the radiation sources was calculated by assuming a person would spend all of their time directly above or at the center of each of the radiation fields. The effects of radioactive progeny were not addressed because all the radionuclides analyzed in this assessment, with the exception of Cs-137 and nickel-63, were short-lived activation products that decay to stable nuclides. Cesium-137 is a predominant fission byproduct with a 30-year half-life that decays to barium (Ba-137 metastable), which undergoes a prompt gamma-ray emission and becomes a stable and natural form of barium. Nickel-63 is also an activation product, but it has a 100-year half-life and it decays to a stable form of copper.

Table 7-8. Soil contaminant screening process for OU 10-04, BORAX-09 (Reactor Bldg.-Post D&D).

		Step 1		Step 2	Step 3		Step 4		Site COPC?	
Detected Contaminants	Max Source Concentration (mg/kg or pCi/g)	INEEL Background Concentration (mg/kg or pCi/g)	Max Concentration > background?	Nontoxic Metal?	Region 9/3 RBC (mg/kg or pCi/g)	Max Concentration > RBC?	INEEL EBSL (mg/kg or pCi/g)	Max Concentration > EBSL?	HHRA	ERA
Arsenic	7.70E+00	5.80E+00	Yes	No	3.90E-01	Yes	8.44E-01	Yes	*	*
Cs-137	1.41E+01	8.20E-01	Yes	No	2.30E-01	Yes	4.95E+03	No	Yes	No
Manganese	4.97E+02	4.90E+02	Yes	No	1.60E+03	No	1.05E+01	Yes	No	Yes
Mercury	1.20E+00	5.00E-02	Yes	No	6.10E+00	No	3.00E-01	Yes	No	Yes

Source: WAG 10, OU 10-04 Database.

"NA" in Step 1 indicates that a background value is not available.

*Arsenic was removed from the ERA and HHRA COPC list because detected concentrations are within INEEL background levels (see discussion in Appendix K).

"No RBC" indicates that an EPA Region 9 or 3 risk-based concentration based on residential soil ingestion is not available.

"No EBSL" indicates that an INEEL ecologically based screening level is not available.

Radionuclide risk-based concentrations were taken from a personal communication from Jeff Fromm, Ph.D., an environmental toxicologist, entitled "Radionuclide Risk-Based Concentration Tables." January 3, 1996.

Table 7-9. Summary Exposure Point Concentrations for BORAX-09 (concentration units are mg/kg or pCi/g; bin depths are in feet).

COPC	0-0.5 ft	0-4 ft	0-10 ft
Cs-137	1.45E+00	1.81E-01	7.25E-02
Manganese	3.99E+02	4.99E+01	2.00E+01
Mercury	1.20E+00	1.50E-01	6.00E-02

The source terms were determined as a result of contamination and radiation surveys performed on the vessels in 1992 and 1993 (Burns 1994) and surveys performed on the contaminated soil removed from the BORAX II/IV reactor pit during 1994 D&D activities (Rodman 1997). The contaminated soil was put into boxes from which random composite samples were collected during 1996. The radiation surveys in 1993 of both reactor vessels confirmed the 1992 contamination smear surveys. The curie totals for the BORAX-II/IV reactor vessel were 0.024 Ci Ba-137m, 0.025 Ci Cs-137, 4.94 Ci Co-60, and 7.2 Ci Ni-63. The curie totals for the BORAX-V reactor vessel were 21.1 Ci Co-60, 0.112 Ci Cs-137, 0.106 Ci Ba-137m, and 140.0 Ci Ni-63. The curie totals for the contaminated soils were 1.44E-3 Ci Cs-137, 1.89E-4 Ci Co-60, and 2.16E-4 Ci Eu-152. The activity totals were multiplied by the source volumes to produce the source term concentrations. The source terms were input into the Microshield program to determine the maximum external exposure rate to the resident individual. The three exposure scenarios were calculated using the 1992 assay date activities with no reduction in source strength as a result of radioactive decay.

The source geometries and shielding information were taken from the EDF (Burns 1994), *Final Report—D&D of Borax V Reactor Building*, INEL-96/0325 Rev. 0 (Rodman 1997), and Track 1 Decision Document for the BORAX-V Reactor Building (DOE-ID 1995a). The three scenarios were performed using the current entombment configuration. There are more than 1.5 m (5 ft) of concrete shielding over the BORAX-V reactor pit and 0.5 m (1.5 ft) of concrete plus 1.2 m (4 ft) of clean soil over the BORAX-II/IV reactor pit that is filled with the contaminated soil. The exposure scenario assumed that the future resident would use the existing concrete cap and foundation over the BORAX-II/IV reactor vessel as the floor of the new residential structure. For the BORAX-V scenario, the closest distance to the BORAX-V reactor that a home basement could be built would be 2.4 m (8 ft). The concrete slab foundation that the BORAX building was placed on extended 2.4 m (8 ft) beyond the edge of the BORAX-V reactor pit. The lateral amount of shielding between the reactor vessel and the hypothetical basement consists of 1.8 m (6 ft) of soil and 0.61 m (2 ft) of concrete.

The Microshield output files are included in Appendix L. Even though the BORAX-V reactor vessel had the largest source term, the exposure rate was the lowest due to the larger amount of shielding. The radionuclide-contaminated soil had the highest contribution to exposure, because it had the least amount of shielding and was physically closer to the exposed individual. The total calculated radiation exposure rate on the surface of the existing concrete slab from the BORAX-II/IV reactor vessel and the contaminated soil in the reactor pit was 1.66E-10 mrem/hr. In essence, the external exposure is negligible. The total calculated radiation exposure rate from the BORAX-V reactor vessel to the floor of the hypothetical basement is 5.84E-19 mR/hr. Again, this exposure rate adds nothing to the existing natural background radiation levels. According to Hoff et al. (1993), the background environmental radiation exposure rate observed near the INEEL is 130 mrem/yr (1.5E-02 mrem/hr).

The radionuclides that produce the external exposure are the gamma ray emitters Cs-137, Co-60, and Eu-152; therefore, the exposure rate is equivalent to the dose rate. This results in a dose rate of 1.66E-10 mrem/hr for the BORAX-II/IV scenario and 5.84E-19 mrem/hr for the BORAX-V scenario. The annual dose for a future resident under the BORAX-II/IV scenario would be 1.4E-06 mrem/yr (166E-10 mrem/hr × 24 hr/d × 350 d/yr). The BEIR V (Biological Effects of Ionizing Radiation) committee (National Research Council 1990) estimates for total lifetime cancer risk are 5E-04 excess cancer mortality per rem of whole body exposure for the general public. Given this conversion factor for cancer mortality risk and the maximum calculated dose rate from the site, the cancer mortality risk is 2.1E-11 (1.4E-09 rem/yr × 30 yr × 5E-04 risk/rem) for a resident. The NCP target range for risk is 1E-04 to 1E-06. The maximum calculated risk for a future resident at the BORAX-II/IV site is well below the NCP target range. The maximum calculation risk for a future resident for the BORAX-V scenario would be even lower. The list of assumptions and calculations appear in Appendix L. The 350 days per year for an annual exposure is the parameter value required by the Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL (Appendix A section A-1.3.4 Residential Scenario). This is the same rationale and reference for the cancer mortality parameter for lifetime exposure being 30 years.

7.3.5.2 Ecological. The COPCs for the ERA are manganese and mercury in the surface and subsurface soil. Only COPCs with HQs greater than 10 will be retained for further evaluation in the ERA. These HQs and COPCs are presented in Table 7-10. COPCs with HQs less than or equal to 10 are eliminated from the ERA because they pose a low risk to ecological receptors and no longer need to be evaluated. Risks from manganese and mercury to reptiles, amphibians, and invertebrates could not be evaluated because of the lack of toxicity data to develop toxicity reference values.

The HQs for the COPCs at BORAX-09 are discussed below:

- The HQs for exposure to manganese ranged from 7 for the deer mouse (M422) and 8 for plants (all vegetation) to 10 for the pygmy rabbit (M122A). The exposure point concentration ranges from 399 mg/kg in the surface soil to 20 mg/kg in the subsurface soils. The INEEL background concentration for manganese is 490 mg/kg. Therefore, a receptor may be exposed to the same magnitude of risk from exposure to background. This

Table 7-10. Summary of ERA HQs for BORAX-09.

COPC Receptors	Manganese HQs	Mercury HQs
Burrowing owl	—	1
Black-billed magpie	—	3
Deer mouse	7	—
Mourning dove	—	3
Plants	9	—
Pygmy rabbit	10	3
Sage sparrow	—	20[a]
Townsend's western big-eared bat	—	2

COPCs with HQs less than one are not presented in this table.

a. See the bulleted discussion on mercury following this table as to why this HQ is not retained in the ERA.

contaminant was eliminated as a COPC, because the HQs were equal to or below 10, which indicates a low risk to ecological receptors.

- The HQs for exposure to mercury ranged from 1 for the burrowing owl (AV322A), to 2 for the Townsend's western big-eared bat (M210A), 3 for the mourning dove (AV122), black-billed magpie (AV422), and pygmy rabbit (M122A), and 20 for the sage sparrow (AV222). The exposure point concentration in the surface soil is 1.2 mg/kg to 0.06 mg/kg in the subsurface soil. The INEEL background concentration for mercury is 0.05 mg/kg. Most of the HQ values fell below the low risk HQ of 10. This contaminant was eliminated as a COPC because the exposure point concentration (1.2 mg/kg) represents the only elevated value above background and it is restricted to a single location in the area. The HQ values from exposure to this contaminant are calculated very conservatively, and therefore, risk from exposure to this COPC would be very unlikely. Consequently, mercury will no longer be retained for evaluation in the ERA at this site.

The risk evaluation indicates that BORAX-09 has limited risk to ecological receptors from exposure to soils from this site. Cumulative risks to ecological receptors from exposure to contamination at all BORAX sites are addressed in the OU 10-04 Ecological Risk Assessment (Section 17).

7.3.6 Uncertainties

The primary area of contamination is belowground and buried with the reactor debris. The remaining radionuclide contamination entombed at the site was an estimation based on data collected during the 1996 D&D activity. Migration of this contamination to groundwater is very unlikely, because all contamination is contained within the concrete subfloor of the original reactor building. Concrete shield blocks are also in place above the contamination.

7.4 Risks to Native American Populations

The INEEL is within the aboriginal territories of the Shoshone-Bannock Tribes. A wide variety of natural and cultural resources and areas that directly reflect tribal cultural heritage and native landscape ecology are preserved at the INEEL. These resources are important in maintaining tribal spiritual and cultural values and activities, oral tradition and history, mental and economic well being, and overall quality of life. Archaeological sites of traditional and cultural importance to the Tribes have been identified in close proximity to the BORAX complex.

Tribal Elders and Shoshone-Bannock Tribal Risk Assessment Committee members visited the BORAX area to assess tribal concerns about WAGs 6 and 10 in March and May 2000. On both occasions, approximately 20 individuals were present. The tribal report that resulted from these visits and the subsequent analysis (Appendix A) contains no specific information on tribal concerns at the BORAX area, but does provide a framework of general concerns centered on impacts to land, air, water, plants, animals, and tribal members. All of these elements are viewed as interconnected. Although it is stabilized, the contamination present at several BORAX sites along with a notable dominance of nonnative vegetation would probably be considered to be of some risk within the framework of general Native American concerns included in the report. Previous D&D activities, long-term monitoring, and periodic reassessment of the area should help to reduce the perceived risk and address the general concerns.

7.5 Cumulative Risks

7.5.1 Human Health

The cumulative human health risk at the BORAX sites includes the risks from exposure to residual contamination in soils at each of the four sites and the risks from subsurface contamination associated with the entombed reactors at BORAX-02 and BORAX-09. The D&D activities and remedial actions at BORAX-02 have effectively eliminated all exposure pathways at this site except groundwater. The OU 5-05/6-01 RI/FS included estimates of human health risk from ingestion of contaminated groundwater for future residents at 30 years and 100 years. The estimated risk contributed by the groundwater pathway at BORAX-02 was 3E-06 (Filemyr 1995). The estimated risk to future residents from external exposure to contamination remaining at BORAX-09 is 2E-11 (see Section 7.3.5.1). The risks posed by subsurface contamination entombed at BORAX-02 and BORAX-09, when added to the risk associated with exposure to surface soils, do not significantly increase the cumulative risk for all the BORAX sites.

7.5.2 Ecological

Cumulative risks to ecological receptors from exposure to contamination at all BORAX sites are addressed in the OU 10-04 Ecological Risk Assessment (Section 17).

7.6 Conclusions and Recommendations

Human health risks at the BORAX sites are within the 1E-04 to 1E-06 target risk range for future residents and future workers. Risk to current workers at the BORAX sites (2E-04) is on the upper end of the target risk range. However, this risk level is mitigated by the lack of any ongoing INEEL operations associated with this site. The BORAX sites pose limited risks to ecological receptors, and no contaminants were retained in the ERA for further evaluation. Therefore, BORAX-02, BORAX-01, BORAX-08, and BORAX-09 are recommended for no further action and will not be evaluated in the feasibility study.

7.7 References

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